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(54) FLOATING DEVICE FOR LAYING A PIPE ON THE BOTTOM OF THE SEA

(71) We, N. V. INDUSTRIEELE HANDELSCOMBINATIE HOLLAND, a Dutch limited liability company, of Rotterdam, the Netherlands, do hereby declare the invention, for which we pray that a patent may be granted to us, and the method by which it is to be performed, to be particularly described in and by the following statement:—

The invention relates to a floating device for laying a pipe or tube on the bottom of a body of water, such as the sea bed. Such a device is known and is manufactured amongst others by Rasco Hydraulics Inc., Dallas, Texas and an example of the embodiment of such a device has been described in Dutch patent application No. 66.05857, which is open to inspection. However, in said known device, wheels for gripping the outside of a pipe to be laid, do not have separate driving motors, but they are coupled with a single driving means.

The pipe lines to be provided on the sea bed and which are used, for example, as transportation means for oil, are usually weighted by means of a concrete covering, in order to prevent them from lifting.

In the part of the pipe line between the vessel and the sea bed, considerable stresses may arise. In order to reduce stresses, it is known to provide the vessel with a supporting element projecting backwards, said element supporting the pipe line at a distance behind the vessel. However, such a supporting element cannot be used in water with high waves, because of the movements of the vessel and their influence on the pipe. With the afore-mentioned known devices, the problem has already been solved in that a tensile stress is created in the pipe with the rotatable elements gripping the outside of the pipe, which results in a slightly curved feed line and prevents undesirable bending stresses. For creating said tensile stress it is, of course, necessary that the vessel be winched ahead using the cable of anchors laid ahead of the vessel. However, measures should be taken to keep as constant a tensile stress as possible, in spite of rolling and pitching of the vessel due to sea conditions. A constant tensile stress is possible with the known device, as each wheel is driven by means of a hydraulic motor to which a fluid is supplied under pressure by a pump, the pump being driven by an electromotor or a combustion engine. With such hydraulic motors, fluid leakage occurs. In addition, a reasonably high power has to be available in order to maintain the pressure in the hydraulic motors, the pressure being necessary for creating the tensile stress.

During pitching of the vessel, longitudinal movements of pipe and vessel relative to one another must be possible. This will be effected in that the wheels roll along the pipe, in other words, the pipe slides between the wheels gripping said pipe and the wheels will move in one direction in accordance with the drive direction of the hydraulic motors and when the pipe slides in the opposite direction, they will move against the pressure of the motors. With the movement in the direction mentioned first, the pipe will be hoisted as it were and the hydraulic motors will supply the energy; with the reverse motion said movement of the pipe will take place opposite to the drive direction, and the energy is nullified.

According to the present invention, there is provided a floating device for laying a pipe on the sea bed, said device consisting of a vessel with a guide for the pipe, as well as apparatus to maintain the pipe under a tensile stress and which apparatus comprises a number of rotatable elements gripping on the outside of the pipe, such as being located in planes running through the wheels provided with tyres, said elements centre line of the pipe and which may grip the pipe and which are coupled with means

for maintaining the tensile stress, wherein each rotatable element is coupled via a brake which can be disengaged or a slip clutch to the axle, on which axle the rotatable element is rotatably borne, said axle being rotatably supported in the frame of the apparatus and being coupled to the movable portion of a power source provided in said frame so that a torque may be transmitted to the axle, said torque exerting a tensile force on the pipe by means of the rotatable elements, said power source being able to deliver energy and accumulate same respectively according to the working direction.

In order to maintain the tensile force, the high power necessary with the known device (Rasco use a diesel engine of 390 h.p. for a 120 ton plant) is not necessary any longer. Considerably less power is sufficient with the same tensile force, e.g. 50 h.p. as it is only necessary to provide the creation of the necessary initial force and some other actions to be described, for example, when a pipe which has already been lowered into the water, has to be hoisted back again, because it is found afterwards that an already manufactured weld seam has to be improved.

In an embodiment, the power source includes a piston cylinder unit the working space of which is connected to a pressure source. The pressure source can be a pneumatic source, however, the power source is preferably hydraulic in view of the high working pressures required. When using a hydraulic system, the working space of the piston cylinder unit is coupled hydraulically to an air loaded accumulator or pneumatic spring where the accumulation of energy takes place, the pneumatic spring acting as the pressure source or power store. Although less attractive, it is conceivable that a spring could be used as the power store. In addition, it is possible to use an electrical power store, provided that said store can deliver energy as well as accumulate energy.

The ability to disengage the wheel from its axle is necessary, as during the rolling motions of the wheel along the pipe, slip occurs to a certain extent, which means a reduction of the usable length of stroke of the compensating or first cylinder, so that it must be possible to re-set said first cylinder to its starting position. As in each device a large number of wheels grip on the pipe, resetting can be done separately with each wheel. In another embodiment, suitable means consist of a second cylinder being provided at each wheel, in which cylinder a force may be created which is opposed to, and which is higher than, the force which may be created by the first piston cylinder unit and which acts on the piston of the first cylinder. When said second cylinder is put in action after the brake has been released, the first cylinder unit will be reset.

Releasing the brake is also imortant when the pipe has to be veered i.e. when the next section of pipe has been attached by welding. It is, of course, important that in veering the pipe, the tensile stress in the pipe be maintained and that also the torque exerted by the first or compensating cylinders remains effective.

In another embodiment, the means for disengaging the brake operate dependently on the angle of dispaclement of the axle and come into action before the piston of the first cylinder reaches its final position. The pipe is veered by hauling the vessel ahead. Thus, the hauling winch or winches must be able to exert a pull which is higher than the tensile force exerted by the pipe line. When this happens, the wheels are forced to move against the pressure in the first cylinder, the motion being superposed on the movement resulting from pitching. As the brake releases (i.e. the slip coupling slips) after a certain angular displacement, the wheels allow the pipe to be lowered, while at the same time the torque on the axle is maintained, because at the moment when the brake starts to release and, thus begins to slip, the first or compensating cylinder wants to reverse the axle to the position in which the brake is again in action. In this way it is possible to veer the pipe in a controlled manner while compensation is maintained, i.e. that a constant tensile stress is maintained in the pipe.

In another embodiment, the brake control lever is kept in its brake position by a spring, and a stop is provided on the frame in the path of the brake control lever so that when the wheel and the axle rotate, the brake is released opposite to the force of the spring acting on the lever when same brake strikes the stop. This is a mechanically simple and solid solution.

In another embodiment, a hydraulic brake cylinder may be provided to move the brake control lever opposite to the force of a spring, said cylinder being connected to a high pressure circuit leading to the second cylinder, said circuit including a control valve, said valve may connect said circuit and the corresponding circuits of all other wheels selectively to a pressure source. It has already been stated above that there may be a second cylinder which may exert a higher force than the first or compensating cylinder and which acts opposed. This is necessary for the resetting which may be required when the piston of the first cylinder comes near the final position by slipping of the wheel along the pipe.

In this case, the brake must be released during said deset of the brake.

It happens sometimes that the pipe has to be hoisted again, and this requires the vessel to be veered on its anchor chain. This will take place while the tensile stress is maintained, as the first cylinders make an operating stroke which is a part of their total length of stroke, because even with this operation the compensating movements must remain possible. At the end of said operating stroke, a re-set must be carried out by connecting re-set or second cylinders in turn to the high pressure circuit via the control valve, with the brake being released each time and the appropriate second cylinder carrying out a re-set stroke, thus returning the axle and the first cylinder to the starting position. The corresponding wheel is disengaged for a short time when supplying the tensile force, which is no objection as this action is performed separately with all wheels.

In a further embodiment the two cylinders, i.e. the first or compensating cylinder and the second cylinder which is opposed, act on the axle via a chain engaging a gear wheel or gear segment. It is, thus possible to keep the torques equal, independently of the rotation of the axle. Moreover, this is a simple, inexpensive and compact construction. The second cylinder is preferably connected to a low pressure circuit in order to keep the chain under tension.

Of course, other constructions are also possible. The compensating cylinder may be manufactured double-acting so that the pressure source acts on one side of its piston and on the other side the re-set pressure may be exerted. When the connection to the axle is also constructed with a chain and a gear wheel, means are necessary to keep the chain taut, for example, a low pressure cylinder.

With the known device, several wheels are located in more than one plane running through the tube centre line, e.g. in two or three planes. In another embodiment of the present invention, the wheels may shift relative to one another within their respective planes. It is, thus, accomplished in the first place that passing a junction in the concrete covering, said junction lying in the same place as the weld seam, and during which passing the pressure of the wheel has to be temporarily removed, may take place without substantial interference with the tensile force which is exerted on the tube by the wheels. Tubes of smaller diameter than the width of the tyres may be accomodated also because the wheels located in the various planes grip the pipe between one another.

In a preferred embodiment of the invention the wheels are located on either side of the tube in mutually perpendicular planes. A relatively compact construction is obtained, which may combine the advantages of the moving grip with the grip each time of the wheel pairs of either side of the tube.

In explanation of the move we now give the following example:

When e.g. three pairs or four pairs of wheels are usd, i.e. six in one plane and eight in the other plane, this means that when a weld seam is passed, only 1/7 part of the wheels is out of action and only 1/14 part does not exert a tensile force during the re-set operations.

It should be noted that the change in the tensile force during the re-set may be nullified by a simultaneous pressure increase in the first or compensating cylinder and by a pressure reduction in the second cylinder respectively.

The device may also be controlled so that always one of the units is disconnected.

It is preferred to provide each wheel with a power source, i.e. a unit comprising two cylinders, rotatable about an axis parallel to the wheel axle but spaced therefrom, in the frame.

Thus, a compact and inexpensive construction is possible. Each unit may have its own pneumatic spring, but it is also possible to connect all units to a common pneumatic spring.

In another embodiment, the structure may include a frame being almost square in cross-section, in which the wheels are located in planes running essentially according to diagonals of the cross-section. Thus, a large setting range is possible for various tube diameters and a compact structure is maintained.

In a further embodiment, each unit may be hinged to a hollow girder secured halfway on either side in the frame, the side faces facing inwardly of said girder and being parallel to the diagonals of the cross-section. Thus, an effective, rigid construction is obtained.

The invention will now be described by way of example and with reference to the accompanying drawings, in which:—

Fig. 1 is an end view of the apparatus according to the invention as may be arranged on a vessel;

Fig. 2 is a side elevation of the apparatus according to the invention;

Fig. 3 is a side elevation, including a hydraulic scheme of a unit, of which several appear in the apparatus shown in Fig. 1 and 2;

Fig. 4 is a cross-section of a partial view of the apparatus shown in Fig. 3.

The apparatus shown in Fig. 1 consists of a rectangular frame 1, the vertical parts of which are formed by a lattice construc-

tion 2 (shown in Fig. 2) between horizontal profiles 3 and 4, said vertical parts being connected to one another on top by a horizontal lattice 5 and being secured on the underside on a foundation with the profiles 4. Hollow girders 6 of substantially triangular section are secured on both lateral lattices and the walls 7 and 8 facing inwardly from the girders run parallel to diagonals 10 and 9 respectively of the substantially square section of the frame1.

Rotatable elements or wheel units 11 are fixed to these hollow girders 6, the units rotating on axles perpendicular to either lateral faces 7 or 8.The wheel units can each have their positions adjusted relative to each other in planes parallel to the planes containing the diagonals of the frame, by means of a handwheel 13 operating a screwed spindle 12 received by a fixed point 14. The wheel units are provided with pneumatic tyres gripping on a tube or pipe 15 to be transported. The spindles 12 not only provide an adjustment to the diameter of the tube but also the regulation of the pressure with yhich the pneumatic tyres act on the tube.

As is shown in Fig. 2, an uneven number of wheel units in the planes 9 and 10 are arranged so that they can move relative to one another. The above-mentioned wheel unit adjustment makes it possible to have an adjustment on the tube diameter, maintaining a compact structure, said diameter being smaller than the width of the pneumatic tyres (as shown in dotted lines in Fig. 1), and during the passing of a weld area not four but only two wheel units need to be disengaged each time.

Each wheel unit will now be described in more detail with reference to Fig. 3 and 4.

Each wheel unit includes a chamber 16, said chamber may swivel and is secured to the hollow girder 6 with a hinge pin 17. The chamber 16 is provided with a fork 18 at the end of the hinge pin 17 which is facing away from said pin. An axle 19 is mounted in said fork 18 and may rotate freely. The spindle 12 is provided with an external screw thread and provided at the lower end with a ball joint and passes through a sleeve 20 provided in openings of the fork legs 18, said sleeve 20 being provided with internal screw thread. A brake anchoring plate 21 is provided on the axle 19, and brake shoes (not shown) are secured to said plate 21. The shoes may grip from the inside on a brake drum 22 to which is secured a rim 23 with a pneumatic tyre 24. A holder 25 comprising a hydraulic cylinder 26 and a spring 27 is provided on the brake anchoring plate 21. The holder, hydraulic cylinder and spring act on a brake control lever 29 via a rod 28, said lever being located in the brake anchoring plate. The arrangement is such that with a clockwise movement of the control lever 29 (shown in Fig. 3), braking action is obtained. Normally, the spring 27 will keep the brake in operating position. Thus, the whole combination of wheel with brake, brake anchoring plate and the axle 19 is supported and freely rotates in the fork legs 18.

A gear segment 30 is provided on the axle, said segment forming a solid body with the axle.

First and second hydraulic cylinders 31 and 32 respectively are provided in the chamber 16, each cylinder receiving a piston with a piston rod. The piston rods are connected to one another via a chain 33 engaging the gear segment 30.

The first cylinder 31 is coupled via pipe 34 to a pressure source comprising an air loaded accumulator or a pneumatic spring 35 which includes a movable piston 36. Pressure may be maintained in enclosure 37 of said spring. In order to prevent gas being absorbed by the hydraulic fluid, and to prevent a build-up of foam, it may be necessary to provide a movable partition between the fluid and the gas, the partition being provided by the piston 36. A movement of the piston in the cylinder 31 results in an increase of the pressure in the pneumatic spring 35. The increased pressure in enclosure 37 of the spring will act to move the piston again to the right side in the cylinder 31. When the tube 15, being gripped by the whels of a numebr of wheel units, makes a longitudinal movement caused by pitching of the vessel, said movement will effect movements of the piston in the cylinder 31 via the continuous connection of wheel, brake, axle, chain segment and chain. A movement in one direction causes gas pressure in inclosure 37 to be increased which will be useful in returning the piston of cylinder 31 to its original position. The choice of pressure in the pneumatic spring therefore determines the degree of tensile stress imparted to the tube by the wheels whose braking is controlled by the interaction of the pneumatic spring and the piston in cylinder 31.

The chain 33 is kept taut by the piston in the second cylinder 32. Cylinder 32 is coupled to a control valve box 40 with a low pressure circuit, by means of pipes 38 and 39. The low pressure circuit comprises a pump 41 driven by the motor 42, a reservoir 43 and a bypass 44 with pressure release valve 45. The control valve box is not shown in the position in which the connection is to the low pressure circuit, but is obvious that such a connection is formed when a manually operated slide valve 46 is moved to the right hand side as

in Figure 3. Furthermore, the pipe 38 comprises a branch pipe 47′ leading to the brake cylinder 26.

When the tube has to be veered, the vessel will be hauled ahead, during which action compensation to the tensile stress must be maintained by the cylinder 31. Hauling the vessel ahead will take place against the pressure of the pneumatic spring acting as the piston in cylinders 31, i.e. the piston moves to the left side in said cylinder and the whole wheel unit with axle and brake plate will turn clockwise. The projection 47 of the brake control mechanism will abut the stop 48 after a movement of a certain angle of displacement, said stop being provided on one of the fork legs 18. When this happens, the brake will be released, allowing the wheel to rotate about its axle, at which moment the cylinder 31 will try immediately to reverse the brake anchoring plate 21 connected to the axle and, thus, to remove the projection 47 from the stop 48. This results in an equilibrium condition, whereby the brake will slip but wheel torque, creating the tensile stress in the tube, will be transmitted.

When it is necessary to bring the tube inboard i.e. to hoist the tube, the cylinder 31 will make operating strokes whilst the vessel is being veered simultaneously. When the pistons in said cylinders 31 reach the end of their stroke, said end point lying at considerable distance from the cylinder end wall in view of the necessary compensating movements, re-setting will be necessary. High pressure is supplied to the cylinder 32 by the valve control box 40, and slide valve 46 via the pipes 38 and 39 and also to the brake cylinder 26 via the pipe 47′ (as shown in Fig. 3). Thus, the brake will be released and the cylinder 32 will exert a force simultaneously sothat the piston in the cylinder 31 will be drawn back, directly after which the high pressure connection is disconnected. Thus, the connection is established again by the brake and the cylinder 31 may make another operating stroke. As shown in Fig. 3, the high pressure may be connected via the slide valve 46 to the pipe 38 (as shown) or to other pipes 52, 53, 54 etc. running to other units, via a high pressure pipe 49 coming from a high pressure pump 50 driven by a motor 51. Instead of the sliding valve means shown in Fig. 3, a rotating valve means may be used, which is driven continuously so that all units make a re-set successively.

WHAT WE CLAIM IS:—

1. A floating device for laying a pipe on the sea bed, said device consisting of a vessel with a guide for the pipe, as well as apparatus to maintain the pipe under a tensile stress and which apparatus comprises a number of rotatable elements gripping on the outside of the pipe, such as wheels provided with tyres, said elements being located in planes running through the centre line of the pipe and which may grip the pipe and which are coupled with means for maintaining the tensile stress, wherein each rotatable element is coupled via a brake which can be disengaged or a slip clutch to the axle, on which axle the rotatable element is rotatably borne, said axle being rotatably supported in the frame of the apparatus and being coupled to the movable portion of a power source provided in said frame so that a torque may be transmitted to the axle, said torque exerting a tensile force on the pipe by means of the rotatable elements, said power source being able to deliver energy and accumulate same respectively according to the working direction.

2. A device according to claim 1, wherein the power source includes a piston cylinder unit, the working space of which is connected to a pressure source.

3. A device according to claim 1 or claim 2 wherein the pressure source comprises a spring.

4. A device as claimed in claim 2 or claim 3 wherein the means for maintaining the tensile stress act hydraulically, and the working space of the piston cylinder unit is coupled hydraulically to a pneumatic spring.

5. A device as claimed in any one of claims 2 to 4 wherein a second cylinder is provided at each rotatable element, in which second cylinder a force may be created which is opposed to and which is higher than the force which may be created by the power source, and which acts on the movable part of the power source.

6. A device as claimed in any one of the preceding claims, including means for disengaging a brake to operate dependently on the angle of displacement of the axle and to come into action before the movable part of the power source reaches its final position.

7. A device according to claim 6, wherein a brake control lever is kept in its brake position by a spring and that a stop is provided on the frame in the path of the lever so that when the rotatable element and the axle rotate, the brake is released opposite to the force of the spring working on the lever when said brake strikes the stop.

8. A device according to claim 7, characterized in that a pressure cylinder is provided, said pressure cylinder may move the brake control lever opposite to the force of the spring, said pressure cylinder being connected to a pressure circuit including the second cylinder and comprising a control valve, said valve connecting said circuit and the corresponding circuits of all other rotatable elements only one by one to a source of pressure.

9. A device as claimed in any one of claims 6 to 8 as dependent on claim 5, wherein the power source and the second cylinder act on said axle via a chain engaging a gear wheel or gear segment.

10. A device as claimed in any one of the preceding claims, in which several rotatable elements are provided in two planes running through the tube centre line wherein the rotatable elements will shift relative to one another within their respective planes.

11. A device according to claim 10, wherein the rotatable elements are located on either side of the tube in mutually perpendicular planes.

12. A device as claimed in any one of the preceding claims, wherein each rotatable element has been provided in the frame with a power source comprising cylinders as a unit rotatable about an axis parallel to the element axle but at a distance therefrom.

13. A device as claimed in any one of the preceding claims, wherein the device comprises a frame almost square in cross-section and that the rotatable elements are located in planes running essentially according to diagonals of the frame being almost square in cross-section.

14. A device according to claim 12 or claim 13 wherein each unit is hinged to a hollow girder secured half way on either side in the frame, the side faces facing inwardly of said girder and being parallel to the diagonals of the cross-section.

15. A device for laying a pipe on the sea bed substantially as hereinbefore described with reference to, and as shown in the accompanying drawings.

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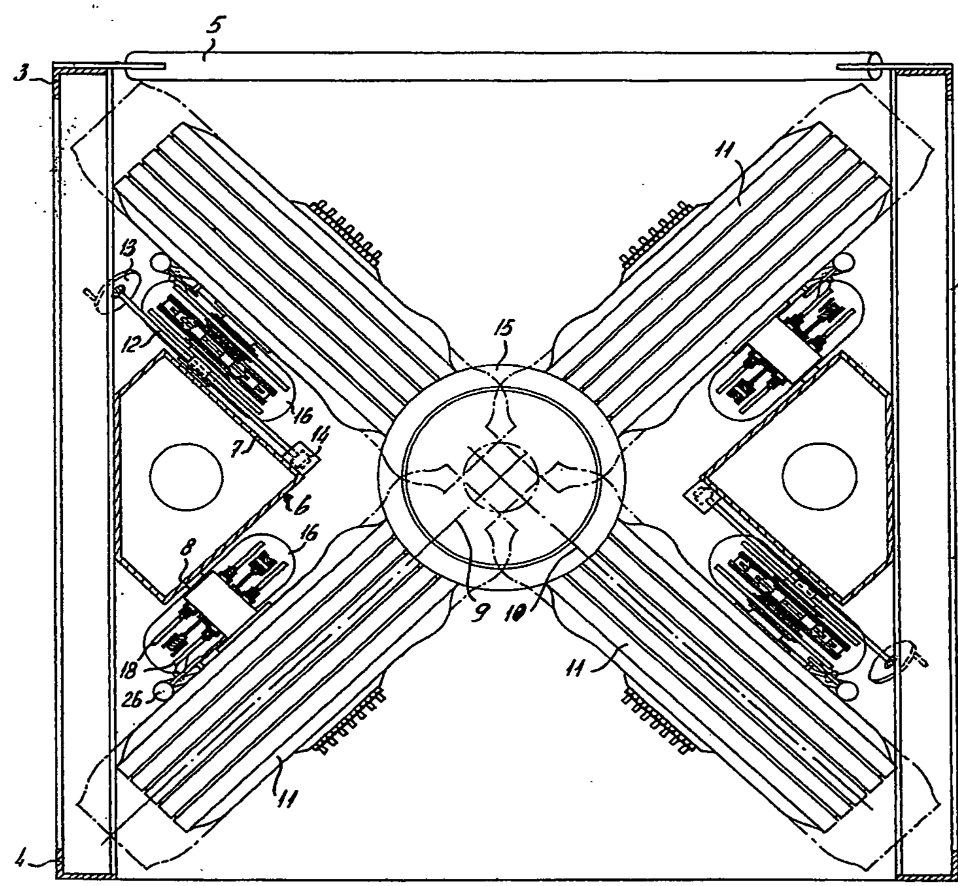
fig-1



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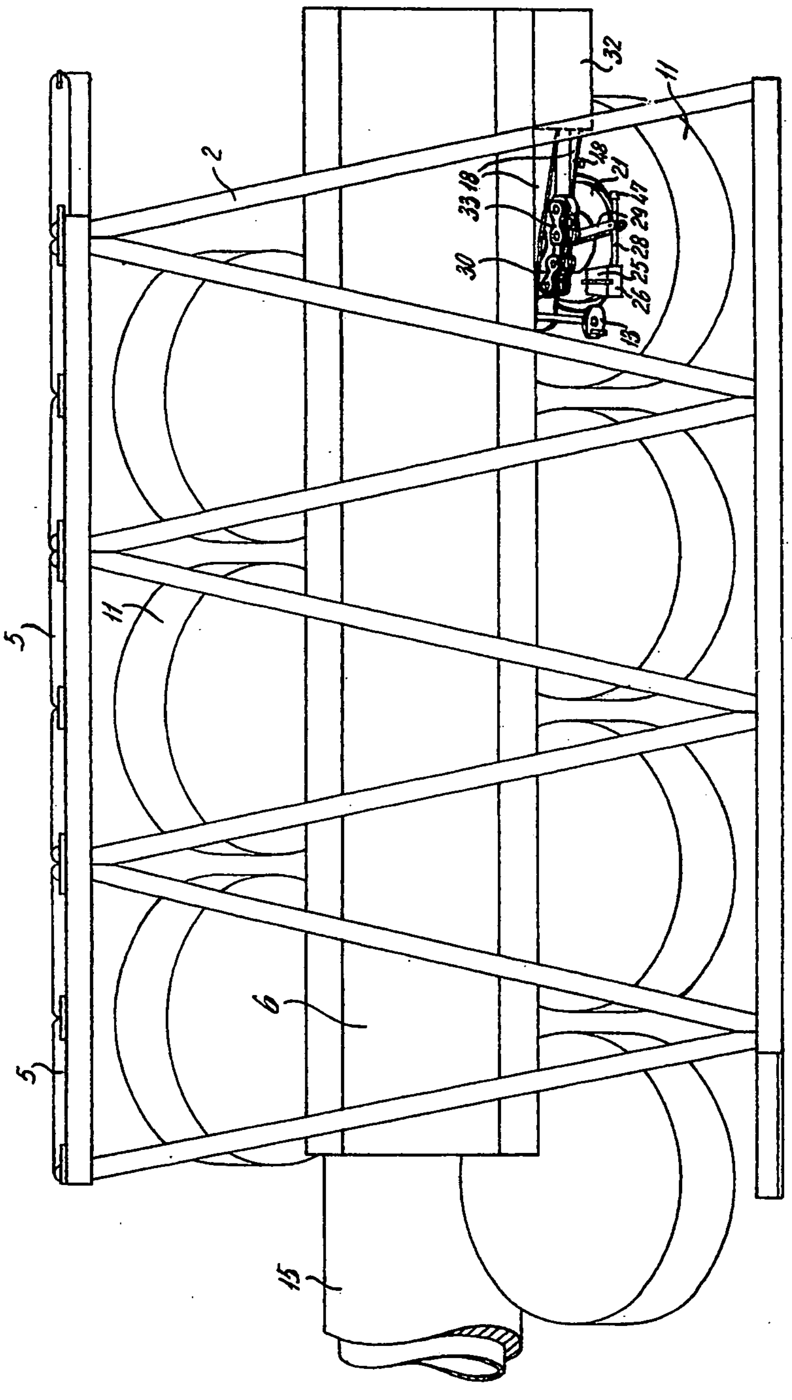
SHEET 2

fig-2



1,250,032 COMPLETE SPECIFICATION
3 SHEETS

This drawing is a reproduction of the Original on a reduced scale.
SHEET 3

fig-3

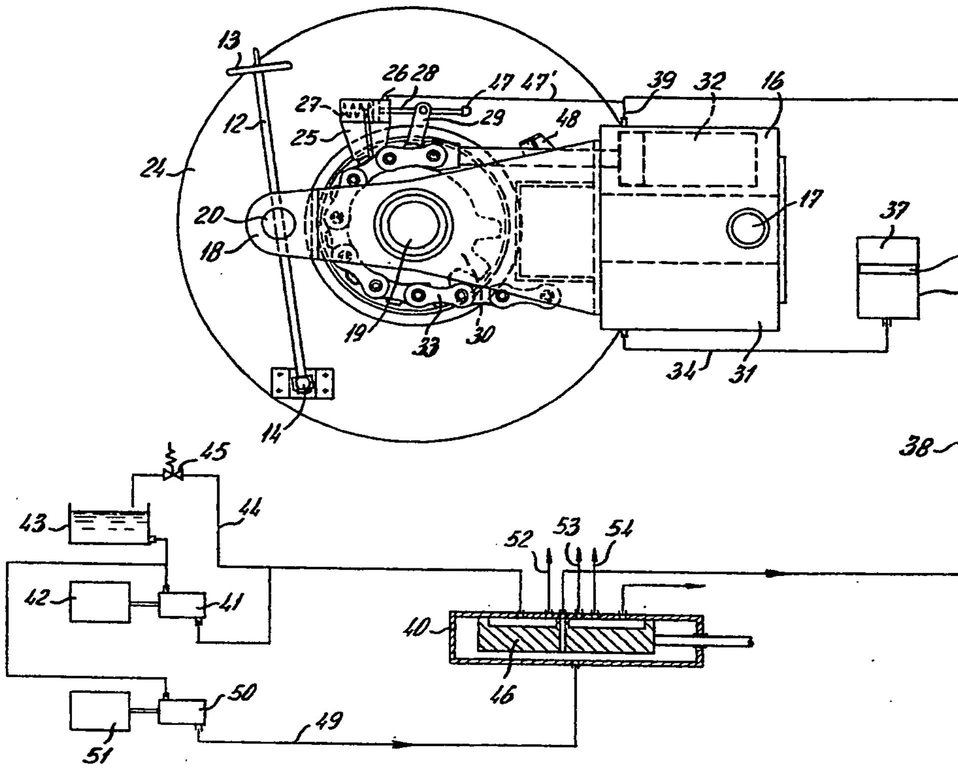


fig-4